DOCUMENT RESUME

ED 389 592 SE 057 236

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TITLE Evolution of a Mathematical Philosophy: The Story of One Secondary Mathematics Preservice Teacher.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Oct 95
CONTRACT DUE-9254475
NOTE 8p.; Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (17th, Columbus, OH, October 21-24, 1995). For entire conference proceedings, see SE 057 177. Research also supported by the Georgia Research Alliance.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Case Studies; Higher Education; *Mathematics; Mathematics Education; *Mathematics Teachers; *Philosophy; Preservice Teacher Education; Secondary Education; *Teacher Attitudes
IDENTIFIERS *Teacher Candidates

ABSTRACT

As mathematics teacher education promotes the mathematics and pedagogical practices of the National Council of Teachers of Mathematics (NCTM) Standards, most mathematics preservice teachers confront philosophies of mathematics significantly different from their personal mathematical philosophy. The constructivist/quasi-empiricist mathematical philosophy espoused by the NCTM "Standards," as opposed to the traditional absolutist philosophy of mathematics as a set of rules and facts, characterizes the conflict in philosophies of mathematics. This report shares the findings from an in-depth case study of a preservice secondary mathematics teacher, Ken, by following the subtle evolution of his philosophy of mathematics, as characterized by Ernest's "Mathematics-Related Belief Systems," and the experiences influential in his philosophical evolution over a year of preservice mathematics teacher education. Contains 12 references. (Author)

Evolution of a Mathematical Philosophy: The Story of One Secondary Mathematics Preservice Teacher

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Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education

(17th PME-NA, Columbus, OH, October 21-24, 1995)

EVOLUTION OF A MATHEMATICAL PHILOSOPHY: THE STORY OF ONE SECONDARY MATHEMATICS PRESERVICE TEACHER

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As mathematics teacher education promotes the mathematics and pedagogical practices of the *Standards*, most mathematics preservice teachers confront philosophies of mathematics significantly different from their personal mathematical philosophy. The espoused constructivist/quasi-empiricist mathematical philosophy promoted by the NCTM *Standards* as opposed to the traditional absolutist philosophy of mathematics as a set of rules and facts characterizes the conflict in philosophies of mathematics. This report shares the findings from an in-depth case study of a preservice secondary mathematics teacher, Ken, by following the subtle evolution of his philosophy of mathematics, as characterized by Ernest's "Mathematics-Related Belief Systems," and the experiences influential to the philosophical evolution over a year of his preservice mathematics teacher education.

Changes in the teaching of mathematics such as those suggested by the NCTM *Standards* will be slow in coming and difficult to achieve because of the basic beliefs teachers hold about the nature of mathematics (Cooney, 1987). Studies in both mathematics education and science education argue that the issue of such change goes further than the beliefs of the teachers, but to the core of those beliefs, the teacher's philosophy (Ernest, 1991a; Schmittau, 1991). The conflict in philosophies of mathematics is characterized by the espoused constructivist/quasi-empiricist mathematical philosophy promoted by the NCTM *Standards* as opposed to the traditional absolutist philosophy of mathematics as a set of rules and facts. In an effort to improve the teaching of secondary school mathematics and secondary mathematics teacher education, the RADIATE[1] research program has focused on the view of mathematics emphasized in the NCTM *Standards* in its experimental secondary mathematics education courses. This research report shares the results of an in-depth case study of Ken, one of the participants of this program, by following the subtle evolution of his philosophy of mathematics, as characterized by Ernest's (1991a) "Mathematics-Related Belief Systems." The documented influences on the adaptations within Ken's philosophy of mathematics provide insight into the psychological aspects of educating teachers.

Methodology

Ken's case study is part of a longitudinal study of preservice teachers that began in April 1994 and will continue into his first few years of teaching. In April 1994 Ken enrolled in the first of a four quarter sequence of secondary mathematics

[1] RADIATE (Research and Development Initiatives Applied to Teacher Education) was directed by Dr. Thomas J. Cooney and Dr. Patricia S. Wilson and funded by the National Science Foundation (#DUE 9254475) and the Georgia Research Alliance. Any opinions or conclusions expressed by this report are those of the author and do not necessarily reflect the views of the funding agencies.

education classes being conducted by the RADIATE staff. A survey and follow up interview during the first two weeks of class elicited initial documentation of Ken's view of mathematics, teaching, learning, and becoming a teacher. He then participated in a curriculum which integrated mathematics content and pedagogy, emphasizing reflection of current and past experiences. The present analysis considers the first year of Ken's preservice experience that includes two mathematics methods courses and his student teaching. Field notes record 44 of the 57 class experiences, one full day of his student teaching, and one full week of his teaching a geometry class during his student teaching. Ken participated in eight guided interviews at regular three to four week intervals and 16 weekly informal interviews developed from the ongoing data. Ken also wrote 25 journal entries to add to the artifacts of tests, reports, and other written class work. Ernest's (1991a) five belief clusters concerning mathematics guided the categorization of statements and dialogue from the data. In the clustered data, interpreted themes and changes within a theme characterized Ken's evolving mathematical philosophy. In addition, literature on teacher change and mathematics teacher education informed the analysis of experiences related to evolution in Ken's mathematical philosophy (e.g., Ball, 1990; Cooney, 1994).

Ken's Philosophy of Mathematics

Upon entering the mathematics education program, Ken's view of mathematics as a set of rules and guidelines that he often referred to as "number crunching" grounded his other mathematics-related beliefs. "Applications, that's for someone else. That's for the engineer, that's for the physicist, and the chemist and things like that.....But me personally, I just like number crunching. Bottom line" (1st Interview, 4/ 7/94). Ken's view of mathematics as "number crunching," of teaching mathematics as "telling" and "lecture," of learning mathematics as "practice, discipline, and memorization," and of assessing mathematics as "objective measures of skill proficiency" reflected what Ken valued from his history of mathematical experiences. Looking for a common thread in Ken's different belief clusters, I interpreted Ken's philosophy of mathematics as "Dualistic Absolutist" (Ernest, 1991b). Ken considered mathematics as certain, made up of absolute truths, and he saw the role of the teacher as an authority on the mathematics for his or her students. Ken's beliefs about mathematics were unquestioned, held without reason or evidence. "Math is what it is." Ken justified his beliefs regarding teaching mathematics, learning mathematics, and assessing mathematics based on the evidence of his experiences in learning mathematics.

Ken's initial philosophy of mathematics is not uncommon among preservice teachers. Like many others, Ken was highly successful with the traditional mathematics he encountered in high school and college. This success with a traditional and dominant absolutist philosophy of mathematics made it difficult for Ken to consider an alternative approach to the mathematics. For instance, when considering approaching basic operations with fractions by using a representation with pattern blocks, Ken commented, "Learning math 'not so good', although I can't say it's bad because this is how I learned it, and I thought it went pretty good, but

learning 'not so good' is to say 'Well if you have two-thirds times one-fourth, what's the answer?'" (Interview, 10/14/94) As illustrated in this excerpt, even when Ken tried to be critical of his algorithmic learning of mathematics he could not discredit the success he enjoyed from learning mathematics from that perspective.

During the 1994 spring quarter, the methods course provided mathematical experiences in a unit on functions that allowed students to explore functions and abstract from the activities patterns or regularities regarding the content as well as the methods. Ken initially responded negatively to the experiences, often rejecting activities shared in the class as unrealistic. Along with the class activities, Ken participated in a high school classroom one hour a week. By the end of the quarter Ken acknowledged a difference between "merely memorizing formulas and definitions and learning algebraic manipulations" and "a quality, in-depth understanding of math concepts" (Report, 5/12/94). An assignment related to reading a section of the NCTM (1989) *Curriculum and Evaluation Standards for School Mathematics* at the end of the quarter provided Ken an opportunity to reflect over his experiences in relation to a culturally accepted alternative. This assignment provided a stimulus for emerging changes in several of Ken's mathematics-related beliefs.

Classes in the fall quarter included four areas of focus: mathematics and culture, geometric constructions, assessment, and transformational geometry. Fall quarter classes also presented a process view of mathematics while attending to more specific pedagogical issues such as equity, group work, assessment, and lesson preparation. Ken worked in a family group with three other preservice teachers to develop lessons and teach on three occasions in the local high school. Of all of the fall quarter experiences, Ken most strongly responded to the assessment unit that emphasized creating problems that tested a deeper understanding of the content.

Ken entered his winter quarter of student teaching with a view of a "deeper understanding" in mathematics that focused on problem solving, reasoning, and meaning to append to his original "Theory of Mathematics." Likewise Ken appended other key components of his "Mathematics-Related Belief System" (Ernest, 1991a) so that (1) learning mathematics now included self-discovery and connecting knowledge, (2) teaching mathematics required investigations for self-discovery in addition to lecture and telling, and (3) assessing mathematics added a need to explain meaning and became a regular part of instruction. Tymoczko's (1986) description of a quasi-empiricist philosophy of mathematics related well to Ken's evolved philosophy of mathematics. Ken's "Theory of Mathematics" reflected a strongly held belief in the absolute existence of an objective mathematics, while his evolved view of a "deeper understanding" of mathematics, which connected to his evolved theories of teaching, learning, and assessing mathematics, focused on the meaning of mathematics developed by mathematical processes of reasoning and problem solving. Without denying a reality in mathematics, Ken began to value the processes of mathematics such as the reasoning and problem solving.

Experiences Related to Evolution in Ken's Philosophy of Mathematics

Green (1971) suggested that the difference between instruction and indoctrination was the provision of opportunities for the individual to radically examine his/her belief systems. This idea of self-examination or reflection became a consistent theme in the experiences related to evolution in Ken's philosophy of mathematics. It was important for Ken to pause in his current experiences to reflect back on both his immediate and past experiences. In so doing, he communicated his examination of his beliefs and the influence his experiences had on those beliefs. Looking at those experiences that were most influential to an evolution in Ken's philosophy of mathematics as communicated in his reflections, two issues arose: the context of the reflection and the effect of the reflection.

Cooney (1994) suggested five contexts that should be a part of mathematics teacher education programs. Of those contexts, four described influential experiences to Ken's evolved mathematical philosophy. First, the influence of Ken's involvement in the mathematical investigations in the spring quarter became a stimulus for Ken's view of a "deeper understanding" of mathematics. These experiences not only provided Ken with a context for learning mathematics from a constructivist perspective, but it also provided him with an occasion to reflect on his experience as a learner of mathematics, the second important context. Although Ken began to consider the importance of a "deeper understanding" of mathematics, it is important to realize that Ken viewed the "deeper understanding" as an addition to the essential rules and procedures of mathematics. Ken's response to learning mathematics from a constructivist perspective is in contrast to what Ball (1990) described in her work with elementary preservice teachers. Ball's preservice teachers often approached mathematics with anxiety and feelings of incompetency. Their experiences with mathematics in the methods class provoked some to reinterpret their past mathematical experiences, gaining new lenses, new assumptions, and new ideas to pursue in mathematics. Ken's self-perceived confidence with mathematics, even calling himself a "math god," inhibited him from considering a reinterpretation of his understanding of mathematics, insisting rather on viewing the "deeper understanding" of mathematics as an addition to traditional mathematics.

In contrast to his reflections of the mathematical experiences throughout the 1994 spring quarter, Ken's reflections stimulated by a reading assignment in the NCTM *Standards* at the end of that quarter provided him with a new lens to view his recent experiences that reflected views accepted by many professional mathematics educators. This new lens allowed Ken to see that there were viable approaches to mathematics that differed from what he understood as the only appropriate approach to mathematics. Although he did not reinterpret grade school experiences with mathematics as Ball's (1990) preservice teachers had, Ken reinterpreted his experiences with mathematics in both the methods class and the high school class in which he worked weekly. Using the context of the *Standards* (NCTM, 1989) to reflect on his recent experiences with a constructivist approach

to mathematics in the methods class and the traditional approach to mathematics in the local high school provided Ken with a perturbation or dissatisfaction in his beliefs regarding teaching and learning mathematics. As documented in other research studies (e.g., Wilson, 1994; Zilliox 1990), the effect of perturbation or dissatisfaction with current beliefs became an important stimulus for change in Ken's philosophy of mathematics.

In addition to (1) the context that allowed a development of a knowledge of mathematics that permits the teaching of mathematics from a constructivist perspective, and (2) the context of reflecting on his experiences as a learner of mathematics, experiences related to evolution in Ken's mathematical philosophy included (1) contexts of gaining experience in assessing students' understandings of mathematics, and (2) contexts that allowed him to translate his knowledge and beliefs about mathematics into viable teaching strategies. From his experiences in the local high schools, his group work within the courses, and the explicit attention given to culture in the fall quarter, Ken began to acknowledge that different learners will learn and understand mathematics in different ways. This acknowledgment was an evolution from his initial view that all students learned the same mathematics through practice, discipline, and memorization. Ken also found technology and assessment as viable teaching strategies that allowed him to bring his evolving beliefs in exploration and deeper meaning in mathematics into action.

Conclusions

The context of Ken's teacher education program combined with the extra opportunities to reflect on the program through the frequent interviews provided Ken with a very conducive environment for change in his mathematical philosophy. Nonetheless, the evolution noted often seemed insignificant. When asked in a later interview if his student teaching would have been different if he had not had the mathematics education classes he said that it would not have been very different. The evolution in his philosophy had been subtle and Ken did not recognize that there were alternative philosophical views of mathematics from which he could choose. Cobb (1994) states that, "the teacher's role is characterized as that of mediating between students' personal meanings and culturally established mathematical meanings of wider society" (p. 15). Ken developed personal meanings for a "deeper understanding" of mathematics through his experiences and he benefited from the culturally established mathematical meanings presented in the *Standards* (NCTM, 1989), yet he possibly could have benefited from more explicit attention to other culturally established choices for viewing mathematics and its teaching. Such explicit attention would have provided what Ernest (1991a) referred to as "higher levels of reflection and self-awareness" (p. 61) as Ken compared alternative philosophical positions with his beliefs. Neither acknowledging choices among culturally established pedagogical perspectives nor experiencing alternative pedagogical practices is enough for providing a rich context that allows preservice teachers to examine their mathematical philosophies. Rather, the mediation of both the culturally established choices in mathematics education and the

personal meanings attributed to alternative perspectives through experience provides a powerful context for instructing preservice teachers.

References

Ball, D. L. (1990). Breaking with experience in learning to teach mathematics: the role of a preservice methods course. *For the Learning of Mathematics, 10*(2), 10-16.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23*(7), 13-20.

Cooney, T.J. (1987). The issue of reform: What have we learned from yesteryear? In Mathematical Sciences Education Board, *The teacher of mathematics: Issues for today and tomorrow* (pp. 17-35). Washington, DC: National Academy Press.

Cooney, T.J. (1994). Teacher education as an exercise in adaptation. In D. B. Aichele & A. F. Coxford's (Eds.), *Professional development for teachers of mathematics* (pp. 9-22). Reston, VA: National Council of Teachers of Mathematics.

Ernest, P. (1991a). Mathematics teacher education and quality. *Assessment and evaluation in higher education, 16*(1), 56-65.

Ernest, P. (1991b). *The philosophy of mathematics education*. Bristol, PA: Falmer Press.

Green, T. (1971). *The activities of teaching*. New York: McGraw Hill.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

Schmittau, J. (1991). Mathematics education in the 1990s: Can it afford to ignore its historical and philosophical foundations? *Educational theory, 41*(2), 121-133.

Tymoczko, T. (Ed.). (1986). *New directions in the philosophy of mathematics: An anthology*. Boston: Birkhäuser.

Wilson, M.R. (1994). One preservice secondary teacher's understanding of function: The impact of a course integrating mathematical content and pedagogy. *Journal for Research in Mathematics Education, 25*, 346-370.

Zilliox, J.T. (1990). *Teacher participation in a mathematics curriculum development project*. Unpublished doctoral dissertation, University of Georgia, Athens.